Biomass assessment for power generation in Sarukhetri block, Barpeta district, Assam

Prepared for Assam Science Technology and Environment Council
Guwahati, Assam

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Contents

Taluka at a glance

:ation	Situated in south- western part of Barpeta district, Assam (90° 40' and 91° 20'E longitude and latitude 26° 10' and 26° 50' N) .	
ɔography and climate	Located in the Brahmaputra plains, the block is characterised by plain and gently undulating topography The climate is moderate during winter and very hot in summer The average temperature varies between 12 ^{0}C to 33 ^{0}C. The average annual precipitation in the district is about 210 cm	
nography	Population(1991 Census)	59 308 (Male.30 651, Female·28 657)
	Scheduled Castes	3 535 (Male·1885 , Female·1 650)
	Scheduled Tribe	2 108 (Male:1057 , Female.1 051)
	Literacy rate	43.51% (Male: 48.27%; Female· 36.48%)
rastructure facilities	Total road length 178.66 km. (Metalled road.15.47 km Gravelled road.133 76 km and Earthen:29 43 km) No of electrified villages· 31	
id-use	Total geographical area	11 677.8 ha
	Net cropped area	7 807 93 ha
	Barren and uncultivable land	33.13 ha
	Land not available for cultivation	1587.99 ha
	Fallow land	373.33 ha
	Cultivable waste land	158 74 ha
	Land under misc trees, groves	509.38 ha
	Grazing land	1 087 16 ha
·iculture	Major crop Paddy Minor crops Wheat, mustard, black gram, potato, sesamum, etc	
estock	Cattle, buffalo, pigs, poultry, and goats. Total livestock population: 41 046 (Cattle: 18 551, Buffalo: 413 Goat: 8180 and Others.13 902	
·ests	61 ha plantation under Social Forestry Division, Forest Department	
'ustry	Rice mills, bell and brass metal, oil expelling, weaving, and handicrafts (cane, bamboo).	

Biomass generation	Woody biomass: 23 941 98 t/year Crop residue: 19 370 29 t/year
Biomass consumption	Wood. 31 068 02 t/year. Crop residue: 17 295 9 t/year.
Biomass surplus	Woody biomass None Crop residue 2 074 39 t/y
Biomass available for power generation	Crop residue:1 025 49 t/y (after discounting 20% processing loss)
Suggested biomass conversion technology	Paddy husk based gasifier system (dual fuel mode)
Potential power generation	1 872.89 kWh/day
Potential installed capacity	78 kW (operating time 24 hours daily) 312 kW (operating time: 6 hours daily)
Plan of action	Nine paddy husk based gasifier systems of different capacities. 50 kW (2), 30 kW (4) and 25 kW (3) are recommended for installation, to 18 villages.

Suggested locations

Gasifier system	Location (*one system in each location*)
50 kW	Bar amrikhowa and Barmara
30 kW	Paschim aladi, Barghopa, Chatla Rangia nadirpa
25 kW	Kamalabari, Sarihakuchi and Katahalburi,

Investment

Gasifier system	Capital cost (Rs)	O&M / month (Rs)	Biomass c Rs /ton
50 kW	811 250.00	36 738.00	Rs 1125.0
30 kW	521 250.00	24 418.00	Rs 1125.0
25 kW	434 375.00	21 369.00	Rs 1125 0

Note: The above costs do not include transmission and distributi costs.

Chapter 1

Introduction and methodology

Introduction

Biomass resources comprise organic matter derived directly or indirectly from forestry and agriculture or livestock activities, namely wood, crop residues, and animal wastes. Given the overwhelming dependence of India's rural population on traditional biomass resources for meeting its energy demand, the effective utilization of such resources requires focused planning efforts. More so, because of the limited options in terms of fuel sources available in rural areas. Though fuelwood continues to be the main domestic fuel in rural households. Fuelwood, agricultural residues and animal dung contribute between 90-95% of the total fuel consumed in domestic sector, and fuelwood alone accounts for 65% (NCAER 1985)

It is estimated that approximately 405 million tonnes of biomass is generated every year in the country (MNES 1999). This includes rice husk, saw dust, sugarcane baggasse, coir-pith, coffee wastes and groundnut shells India has a potential of generating 19 500 MW of power by processing biomass through cogeneration, combustion and gasification routes (MNES 1999)

Objective of the study

The proposed study is being conducted under MNES's taluka level biomass assessment and power generation initiative. The overall objective is to assess the availability of biomass resources for gasifier based power generation in Sarukhetri block of Barpeta district, Assam. The key parameters studied are as follows

1. Assessment of availability, production and utilization of biomass in Sarukhetri block, Barpeta district in Assam through household/village/block level primary survey.
2. Estimation of surplus biomass availability in the block, which could form the basis for planning for power generation.
3. Assessment of quantum of electricity to be generated from biomass gasification in the selected block and capacity of power plants to be installed.

Methodology

The study is primarily designed to estimate the availability of likely surplus biomass for power generation in Sarukhetri block, Barpeta district, Assam and the power requirements of the block. The focus is on crop residues and woody biomass. Secondary data supplemented by primary survey of all the villages in the study block are the basis

of the estimations made. For the present study, secondary data have been reconciled with primary data collected for corroborating the total information requirements

1.3.1 Secondary data collection

Detailed information was sought from the secondary sources. Data related to demographic, social, and economic parameters were collected to understand the land use pattern, resource management systems, productivity of biomass, etc. In addition, information was obtained for assessing the technical feasibility of biomass based power generation without putting unsustainable pressures on the biomass resource. Apart from the available literature, most of the data collected was based on personal interactions with relevant agencies (Agriculture Department, PWD, Forest Department, Veterinary Department, ASEB, Directorate of Industries, etc.) as also with knowledgeable individuals and organizations. Table 1 1 provides the details on the type and source of the data collected.

Table 1.1 Type and source of secondary data

Information	*Source*
District headquarters	
Census records and district profile	Deputy Commissioner's Office, Barpeta, Directorate of Census, Economics & Statistics Department
Land use, Cropping pattern, Irrigation schemes	District Agriculture Office
Kerosene supply	District Supply Office
Industrial profile	Directorate of Industries
Power supply and consumption	ASEB, Barpeta sub division
Forest area, sustainable yield of forests	Divisional Forest Office (DFO) Forest Survey of India
Block level	
Households, Population, infrastructure	Directorate of Census Operations, Circle Office, Block Development Office,
Land use, grain production, irrigation systems, agriculture markets, water supply facilities	Village level extension Worker, Agriculture Extension Officer, Circle officer
Industries	District Industries & Commerce Centre
Power supply and consumption, Kerosene supply	ASEB Barpeta Sub division, District Supply Office

1.3.2 Selection of villages

For the proposed study, 61 villages out of the total 65 villages in Sarukhetri block were taken into account The remaining four villages were not considered because of logistical constraints. Out of 61 villages, 57 villages are inhabited and were surveyed for primary data collection. The list of the villages was provided by the Block Development Office and Circle Office. However, this did not include the Sarthebari town (urban area), therefore for the computation of surplus biomass resources, this town has been excluded from the proposed study.

3 Primary data collection

Primary data were collected from the surveyed villages to ascertain the resources available and their utilisation patterns, and the prevalent socio-economic practices An assessment was made of the electricity consumption and likely demand, crop residue availability, fuelwood use and infrastructural needs. In the surveyed villages, structured questionnaires were administered at the household level as well as village level Group discussions were held to seek the willingness of the populace as suppliers of feedstock for the biomass based power generation facilities. The details on the type and source of information collected are presented in table 1.2

Table 1.2 Type and sources of primary information .

Information	*Source*
Population, industries, land use, agriculture crop production, development of service sector, etc	Village headman, Panchayat Secretary, households, commercial establishments, local shopkeepers
Livestock, biomass collection and consumption, agriculture development, market prices, etc	Households, commercial establishments, village headmen
Power consumption pattern, biomass processed or consumed, electricity consumption, kerosene/diesel consumption, power cuts, operational periods, etc	Commercial establishments, restaurants, and households, ASEB

Data analysis

To assess the biomass supply from the various sources and its consumption by different end-users and the surplus available, computations were based on secondary and primary information. Probable sites for power generation are identified and constraints associated with the proposed power generation reviewed. The following methodology was used to arrive at the estimations.

1 Agriculture residues

This is a factor of agricultural area, crop type, the grain yield and grain to residue ratio.
Residue production (t)= crop production (t) × residue production ratio

2 Woody biomass

The major sources of woody biomass are individual homesteads as no forest area is found in the study block. Therefore biomass availability from forests is not taken into account However, plantations established by Social Forestry Division, Forest Department comprise potential source of woody biomass. Thus the biomass supply from such plantations has been taken into account

Total growing stock = Area under different categories of land (homesteads, plantations, miscellaneous trees and groves) × plant productivity[1] (cu m/ha)

Annual Sustainable Yield (t) = 1% of total growing stock × density of wood[2]. This is also the maximum available sustainable yield on annual basis in tonnes.

4 3 *Assessment of biomass consumption*

For the domestic sector, use of fuelwood for different end-uses including cooking and space heating at the household level was assessed to obtain the annual household wood consumption at the block level. Similarly, for crop residues, the quantum used for end-uses of fodder and manure is discounted from the total residue production to estimate the surplus. In addition, fuelwood and crop residue harvesting and disposal practices, and transportation arrangements, and prevalent market prices of biomass were also studied at the village level. The commercial sector in the block comprises mainly of shops and restaurants, wherein mainly firewood is utilised for cooking. The industrial sector consisting of small-scale units such as bell metal, rice mills and oil mills consume coal and diesel, respectively to run their operations. Only rice mills are both biomass consuming (as raw material) and generating units

Annual domestic fuelwood consumption = number of households × average fuelwood consumption (kg/day) × 365 days

Annual commercial fuelwood consumption = number of establishments × average commercial fuelwood consumption (kg/day) × 365 days

.4 *Assessment of kerosene consumption*

Kerosene consumption is calculated on the basis of primary survey at household level. **Annual kerosene consumption at block level = number of households × average household consumption (litre/month) × 12 months**

.5 *Power consumption in domestic sector*

Power consumption by domestic sector was calculated on basis of primary surveys as well as secondary data collected from ASEB, Barpeta Sub-Division

Total annual consumption (kWh/year) = Average household power consumption (kWh/month) × Total households × 12 months

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1 Forest Survey of India 1996. Inventory of Forest Resources of India

2 Forest Survey of India 1996. Fuelwood, Timber & Fodder from Forests of India

6 Power consumption in commercial sector

Power consumption by commercial sectors is calculated on basis of secondary data provided by ASEB records

7 Power consumption in industrial sector

Power consumption by industrial sector is computed from data obtained from primary survey as well as ASEB records

Total annual consumption (kWh/year) = Average industrial power consumption (kWh/month) × Total industrial consumers × 12 months

Power generation potential

Biomass based power generation is dependent on the type of biomass conversion technology to be adopted and feedstock to be used Biomass conversion technologies are under refinement and the input-output ratios are being standardised for various feedstock, especially for dual fuel mode based gasifier units. For the proposed study, the potential for power generation is calculated for gasifiers operating on dual fuel mode technology.

In a gasifier based dual fuel mode of operation, the specific fuel consumption per unit generation is as follows.

Wood: 1.0 kg/kWh and Diesel: 100 ml/kWh (Jain 1994)

Crop residue: 1.5 kg/kWh (Ankur 1998)

Chapter 2

Profile of taluka

Barpeta district

The Barpeta district lies between longitude 90° 40' and 91° 20'E and latitude 26° 10' and 26° 50' N. The district shares its boundary with Bhutan in north, Kamrup and Goalpara district in south, Nalbari district in east and Bongaigaon district in the west. The total geographical area of the district is 3 245 sq. km (Assam State Gazetteer 1999) and is divided into two administrative Sub-divisions: Barpeta and Bajali. These are further sub-divided into eight revenue circles. Barpeta, Barnagar, Baghbor, Kalgachia and Sarthebari under Barpeta Sub division and Sarupeta, Bajali and Jalah under Bajali subdivision encompassing 1067 villages spread over 150 Gaon Panchayats (District Agriculture Office 1999).

1.1 *Topography and soil*

Located in the Brahmaputra Plains, the district is characterised by plain and gently undulating topography. There is only one hill called Baghbar hill situated in Mandia block of the district. The Brahamaputra and its tributaries Pahumara, Beki, Manah and Pollah flow through Barpeta. Among the seven genetically classes of soil found in Assam, the old alluvial soil and the riverine soils consisting of recent riverine, old alluvial and peat soils are found here (Assam State Gazetteer 1999).

1.2 *Climate*

The climate of the district is moderate during winter and very hot in summer. The average annual temperature varies between 12°C and 33°C. Temperatures start rising from March and reach the maximum in August whereas minimum temperatures occur in January Rains are experienced from April onwards and the heaviest rainfall occurs during May and June. From November to January there is negligible or almost no rainfall. The average annual rainfall received is about 210 cm (District Agriculture Office 1999).

2 Sarukhetri block

Sarukhetri block occupies the southeastern part of the Barpeta district To its east lies the Nalbari district; Chenga block towards south; and Barpeta block in the west, and Bajali block to its north (Annex 1). The block falls under the administrative jurisdiction of Sarthebari Circle, which belongs to the Barpeta sub-division. Sarukhetri block has seven Gaon Panchayat (GP) consisting of 65 villages under its jurisdiction. The total geographical area of the block is 117.27 sq km

2.2.1 Demography and socio-cultural profile

The population of Sarukhetri block is mainly rural, accounting for 4.28% (59 308 persons) of the district's total population (as per1991 Census) The total number of households in Sarukhetri is 9 226 (Rural Primary Census Abstract 1991) The density (505 persons/sq. km) of population in the block is more than the corresponding figure for the district (427 persons /sq km) The literacy level in the block is 43.51% with low (36.48%) female literacy (1991 Census) The percentage of scheduled caste and scheduled tribe population in the block is 5.96% and 3.55%, respectively. The local inhabitants in the block are mainly Assamese speaking Hindu and Muslim communities.

2 2.2 Infrastructure facilities

The infrastructural facilities in the block are not well developed with only 31 villages of the total 57 surveyed villages being electrified and about 25% of the households being electrified. The total road length in the block is about 178.66 km consisting of metalled, gravelled and earthen roads (PWD 2000). The villages are connected by both fair weather and gravel roads with the block headquarters at Sarthebari. The common modes of transportation here are autorickshaw, bullock cart and cycle Though there is regular bus service from the block HQs to Barpeta, Nalbari and Guwahati, but the frequency is very low. The nearest railway stations are at Pathsala and Sarupeta, which are about 20 km from the block. Educational facilities available in the block ranges from primary to higher secondary schools, but lacking in basic classroom facilities (Table 2.1). There is also a college located in Sarthebari. The local population has access to primary health centres and dispensaries.

Table 2.1 Infrastructure facilities in Sarukhetri

Facility	Number
Schools (Primary, Middle and High)	105
Higher Secondary	9
College	1
Navodaya Vidyalaya	1
Health centres	5
Veterinary hospital	1
Post office (incl Sub post office)	4
Co-operative society	80 +
Bank	7
Daily market	25

Source Circle Office, Sarukhetri 2000

There are two post offices and one telegraph office, and seven banks (nationalised and rural co-operative) in the block Hand pumps, tubewell and community well/taps are the common sources of water Almost all the surveyed villages have tube wells and community wells Though community water taps are available in about 14% of the villages, but because of irregular supply, households depend largely on tubewells and community wells. There are about 25 daily markets and more than 80 co-operative societies. Sarthebari town, which is also the block HQs, is famous for the bell and brass metal industry with about 350 such units located in the town

,2.3 Land use

Given the availability of relatively flat terrain coupled with high population density in the block, land is intensively utilized for agriculture and homesteads (Table 2.2). The total cropped area here accounts for more than 80% of the total geographical area. Farmers grow a host of agricultural and horticulture crops, chief among them being paddy

Table 2.2 Land use pattern in various gram panchayats (GP) of Sarukhetri block

Land use in G P (*Area in hectares*)	*Dakshin Pub Sarukhetri*	*Dakshin-Paschim Sarukhetri*	*Madhya Sarukhetri*	*Madhya Paschim Sarukhetri*	*Paschim Sarukhetri*	*Uttar pub Sarukhetri*	*Pub Sarukheti*
Geographical area	1232 9	2342 4	1342 0	1362	2040	833	2525 5
Forest area	None	None	None	None	None	None	None
Total Cropped area	1045 97	2193 6	966 0	1197 6	1931 0	691 4	1972 0
Net cropped area	840 8	1720 13	814 7	915 3	1570 4	504 7	1441 9
Barren and uncultivable land	0 3	-	-	-	21 34	9 54	1 95
Land not available for cultivation	229 3	303 0	164 79	271 5	207 8	146 0	265 6
Fallow land	31 38	92 55	100 46	31 84	48 5	15 9	52 7
Cultivable waste land	8 84	62 04	2 0	11.9	31 0	14 0	28 96
Land under misc trees, groves	66 45	86 34	69 3	43 36	39 1	34 6	170 23
Grazing land	52 1	119 4	190 36	79.9	86 0	64.6	494 8

Source Circle Office 2000

2.2.4 Scenario of EB substations

Twenty-six substations of various capacities (16kVA, 25 kVA, 63 kVA, 100, kVA) have been set up for distributing power in the block (Annex 2). The ASEB, Barpeta Electrical Sub-division is responsible for the operation and maintenance of these substations (Table2 3)

Table 2.3 Distribution of EB substations in Sarukhetri

Capacity	**16 kVA**	**25 kVA**	**63 kVA**	**100 kVA**
	Besimari pam	Agdia	Bhogdia	Belbari gaon
Villages	Byashkuchi	Barkapla	Byashkuchi	Khudra Amrikhowa
where EB	Dubadubi pathar	Karakuchi	Chinadi	Namsala
sub stations	Gahia	Namsala	Haldibari	Rowly
are located	Harighata		Kamalabari	
	Jasodhar pam		Khudra Gomura	
			Kukarpara	
			Lachima	
			Majdia	
			Palla (2 nos)	
			Singra	
Total	6	4	12	4

Source ASEB, Barpeta Electrical Sub Division 2000

Chapter 3

Baseline data

3.1 Per capita energy consumption

Table 3.1 Per capita annual energy consumption in Sarukhetri

Type of fuel	*Total consumption*	*Total population (Persons)*	*Per capita annual energy consumption*
Firewood (t/y)	31 068 02	59 308	0 523
Kerosene (kl/y)	2 144 76	59 308	0 036
Coal (Q/y)	3 610 0	59 308	0 060
Diesel (lit/y)	63 825 0	59 308	1.076
Cow dung (t/y)	4 743 63	59 308	0 079
Electricity (MWh/y)	16 323 68	59 308	0 275

Source Primary survey 2000

3.2 Domestic electricity consumption

Table 3.2 Domestic electricity consumption

Sl No	Village	No of house-holds	Households electrified	Electricity consumption kWh/month	Annual electricity consumption kWh/year
1	Chatla	213	Unelectrified	-	-
2	Gahia Chatla	261	Unelectrified	-	-
3	Khudra Bamunbari	144	Unelectrified	-	-
4	Garaimari	252	10	540	6480
5	Gadeshali pam	209	Unelectrified	-	-
6	Kaldia	-	Unelectrified	-	-
7	Majdia	345	70	4620	55440
8	Kukarpara	228	15	890	10680
9	Kathalbhuri	49	Unelectrified	-	-
10	Bhogdia	129	10	540	6480
11	Khudra faladi	262	40	2373	28476
12	Bar faladi	10	Unelectrified	-	-
13	Byashkuchi	570	210	13510	162120
14	Balartari	UNINHABITED			
15	Bagrirtari	64	Unelectrified	-	-
16	Barbilor pathar	UNINHABITED			
17	Kamalabari	75	Unelectrified	-	-
18	Pub-aladi	25	Unelectrified	-	-
19	Dubadubi pathar	19	5	280	3360
20	Agdia	4	Unelectrified	Data not available	

21	Lachıma	263	100	7266 67	87200
22	Kaldia pathar	21	Unelectrıfied	-	-
23	Kamarpara	123	30	1620	19440
24	Haldhıbarı	288	35	1890	22680
25	Belbarı	233	25	1850	22200
26	Barkapla	109	100	6075	72900
27	Belbarı pathar	132	100	5600	67200
28	Jashodher pam	191	20	880	10560
29	Rowlı	120	70	2753 33	33040
30	Bhokuatepa	290	200	9600	115200
31	Barmara	271	Unelectrıfied	-	-
32	Bayasa	269	50 .	2550	30600
33	Pachım aladı	41	Unelectrıfied	-	-
34	Rangıa	149	Unelectrıfied	-	-
35	Rangıa nadır pam	177	Unelectrıfied	-	-
36	Bhogchara	154	Data not avaılable		-
37	Kaljahı pathar	95	8	352	4224
38	Burıkhamar	156	12	392	4704
39	Bechımarı pam	444	25	1037 5	12450
40	Gahıa	196	60	3560	42720
41	Garartarı	66	Unelectrıfied	-	-
42	Sıngra	172	35	1977 5	23730
43	Agdıa pathar	58	9	666	7992
44	Harıahkuchı	28	Unelectrıfied	-	-
45	Borgomura	34	20	1386 67	16640
46	Khudra gomura	192	160	8640	103680
47	Karakuchı	208	90	7140	85680
48	Namsala	290	200	14200	170400
49	Palla	136	50	2262 5	27150
50	Barsala bıllar pathar	19	-	-	-
51	Harıghata	71	30	1747 5	20970
52	Harıadı	1	Data not avaılable		
53	Khudra Amrıkhuwa	609	120	5920	71040
54	Now kuchı	10	Unelectrıfied	-	-
55	Bar Amrıkhuwa	209	Unelectrıfied	-	-
56	Chınadı	200	50	2950	35400
57	Balıpara pam	12	Unelectrıfied	-	-
58	Balıpara pathar	26	Unelectrıfied	-	-
59	Patlarkur	33	Unelectrıfied	-	-
60	Borghopa	19	Unelectrıfied	-	-
61	Dewan khetrı	4	Unelectrıfied	-	-
62	Khudra chınadı	5	Data not avaılable		
63	Khapanıkuchı	4	Data not avaılable		
64	Chınadı pathar	UNINHABITED			
65	Chengdı	68	Unelectrıfied	-	-
	Total			**115 069 7**	**1 380 836.4**

Source Prımary survey 2000

3.3 Village-wise energy consumption

Table. 3.3 Annual village-wise energy consumption

Sl No	Name of village	No of HH	Total annual energy consumption Fuel wood (t/y)	Kerosene (kl/y)	Cowdung (t/y)*
1	Chatla	213	719 94	30 672	-
2	Gahia Chatla	261	1072 71	39 15	-
3	Khudra Bamunbari	144	350 58	19 01	-
4	Garaimari	252	1013 04	37 8	-
5	Gadeshali pam	209	762 85	30 1	-
6	Kaldia	UNINHABITED			-
7	Majdia	345	1259 25	. 55 06	629 63
8	Kukarpara	228	889 2	31 90	
9	Kathalbhuri	49	151 9	5 29	89 42
10	Bhogdia	129	392 16	17 49	235 43
11	Khudra faladi	262	542 34	31 44	478 15
12	Bar faladi	10	23 7	1 08	18 25
13	Byashkuchi	570	1373 7	75 92	-
14	Balartari	UNINHABITED			
15	Bagrirtari	64	140 16	7 68	116 8
16	Barbilor pathar	UNINHABITED			
17	Kamalabari	75	183 75	9 45	136 88
18	Pub-aladi	25	105 75	3 9	85 78
19	Dubadubi pathar	19	57 57	2 51	34 68
20	Agdia	4	-	-	-
21	Lachima	263	1151 94	37 87	-
22	Kaldia pathar	21	76 65	3 28	76 65
23	Kamarpara	123	250 92	17 71	-
24	Haldhibari	288	1229 76	21 77	-
25	Belbari	233	850 45	27 14	-
26	Barkapla	109	267 05	12 16	-
27	Belbari pathar	132	370 92	19 48	-
28	Jashodher pam	191	683 78	15 47	244
29	Rowli	120	306 6	9 36	-
30	Bhokuatepa	290	1428 98	34 8	-
31	Barmara	271	1236 44	34 44	39 67
32	Bayasa	269	916 39	35 51	490 93
33	Pachim aladi	41	149 65	6 40	149 65
34	Rangia	149	-	-	-
35	Rangianadir pam	177	453 12	1062	-
36	Bhogchara	154	-	-	-
37	Kaljahi pathar	95	401 85	11 86	138 7
38	Burikhamar	156	683 28	13 10	227 76
39	Besimari pam	444	1296 48	23 98	1296 48
40	Gahia	196	599 76	19 99	-
41	Garartari	66	240 9	6 67	-
42	Singra	172	395 6	12 38	-
43	Agdia pathar	58	175 74	4 87	105 85

44	Harahkuchi	28	102 2	1 68	-
45	Bargomura	34	88.87	1.14	-
46	Khudra gomura	192	443 84	28 42	-
47	Karakuchi	208	609 4	28 70	-
48	Namsala	290	1058 5	33 64	-
49	Palla	136	579 13	16 86	-
50	Barsala pathar	19			-
51	Harighata	71	259 15	7 1	-
52	Hariadi	1	Data not available		
53	Khudra Amrikhuwa	609	2222 85	105 97	-
54	Now kuchi	10	36 5	0 96	-
55	Bar Amrikhuwa	209	508 82	27 59	-
56	Chinadi	200	730	36	-
57	Balipara pam	12	-	-	-
58	Balipara pathar	26	-	-	-
59	Patlarkur	33	120 45	2 77	-
60	Borghopa	19	1387	5 7	-
61	Dewan khetri	4	11 68	0 72	-
62	Khudra chinadi	5	Data not available		
63	Khapanikuchi	4	Data not available		
64	Chinadi Pathar	UNINHABITED			
65	Chengdi	68	289 57	9 52	148 92
	Total		**30 610 82**	**2 135.462**	**4 743.63**

Source Primary survey 2000

* The use of cowdung as fuel source is prevalent only in villages with dominant muslim and hindu bengali communities

Note LPG is also being used for cooking by some households On an average a household consume about 1 5 cylinders per month Such households though use LPG for cooking but do not depend completely on LPG because of chronic shortage and have maintained provisions for firewood cookstoves in addition to LPG

3.4 Industry level energy consumption

Table 3.4 Industry level energy consumption

		Annual average energy consumption			Annual energy consumption		
Type	No of units	Diesel (lit/y)	Elect (kWh/y)	Coal (t/y)	Diesel (lit/y)	Elect* (kWh/y)	Coal (t/y)
Rice Mill (>5 HP)	2	-	6300	-	-	12600	-
Rice Mill (5 HP)	37	1725	-	-	63825	-	-
Bell/brass metal	86	-	-	4 2	-	-	361
Oil mill	2	-	7200	-	-	14400	-
Flour mill	1	-	4800	-	-	4800	-
Total					**63 825**	**31 800**	**361**

Source Primary survey 2000

* The total annual electricity consumption by industrial units as given by ASEB, Barpeta is 1 43 760 units The discrepancy in the primary and ASEB records is due to the inclusion of Sarthebari town by ASEB

3.5 Energy consumption of commercial activities/public utilities, agricultural activities and other misc. activities

Table 3.5 Energy consumption of commercial activities

Type of consumers	Annual energy consumption			
	Fuelwood(t)	Coal (t)	Kerosene (lit)	Electricity (kWh)
Commercial activities	457 2	-	9000	196 320
Public utilities	-	-	-	9912
Institutional	-	-	300	13500
Total	**457.2**		**9300**	**219732**

Source Primary survey 2000, ASEB 2000

Chapter 4

Biomass generation as per land area classification

Biomass from forests

Sarukhetri block comprises 7 *Gaon* Panchayats (GP) covering an area of 117 27 ha Although the Barpeta district has about 26% of its total area under forests, the study block has no record of Reserve Forests as informed by the Circle Office and the Forest Department However, the Social Forestry Division has established 61 ha of plantations (DFO, Social Forestry Barpeta, 2000) in the vicinity of Sarukhetri The annual biomass production from such plantations is 6323 99 tonne and the sustainable yield is 63 24 tonnes/year (Table 4 1).

Table 4 1 Biomass generation from social forestry

Land type	Area (ha)	Productivity[1] (m^3/ha)	Total growing stock (m^3/y)	Total growing stock (t/y)	Sustainable yield (1% of growing stock) t/y
Social forestry	61	129 59	7904 99	6323 99	63 24

Source DFO Social Forestry Division, Barpeta 2000

Biomass from homesteads

Homesteads comprise the primary source of fuelwood for various end-uses in the local households of the block. The composition of vegetation in the homestead includes trees (*jackfruit, mango, jamun, farish, guava, betelnut, coconut, etc*), bamboo and shrubs The annual biomass production from homestead is 13 339 2 tonnes (Table 4 2)

Table 4 2 Biomass generation from homesteads

Land type	Area (ha)	Biomass type*	Productivity[2] (t/ha)	Total growing stock (t/y)	Sustainable yield (1% of growing stock) t/y
Homestead	1588	Wood and bamboo poles	8 4	13 339 2	133 39

Source Circle Office 2000

*Out of the total area under homesteads, 80% is fruit bearing trees and remaining 20% is bamboo plantation, as informed by the villagers during primary survey

[1] Forest Survey of India 1996

[2] Hazarika N, Agarwal S et al 1997

4.3 Biomass from grazing lands, cultivable waste land and others

The biomass available in grazing land, cultivable wastes, fallow land, barren lands, etc is usually grass and shrub. Such lands are scattered and are not restricted to any area in the block The annual yield from such lands is 7 357.45 tonnes (Table 4 3)

Table 4.3 Biomass generation from miscellaneous lands

Land type	Area (ha)	Biomass type	Productivity[3] (t/ha)	Total growing stock (t/y)	Sustainable yield (t/y)
Barren land	33 13	Shrubs	1 4	46 38	0 46
Fallow land	373 33	Grass, shrubs	3 4	1269 32	12 69
Cultivable waste land	158 74	Grass, shrubs	3 4	539 72	5 40
Land under misc trees, groves	509 38	Tree	8 4[2]	4278 79	42 79
Grazing land	1087 16	Grass	1 5	1630 74	16 31

Source Circle Office, Sarukhetri 2000

4.4 Biomass from agriculture land

Paddy is the major agricultural crop of Sarukhetri and covers an area of 6081 84 ha It accounts for 73.63% of the block's total cropped area. Other crops grown here include wheat, mustard & rapeseed, black gram, jute, sesamum, *arhar*, potato and vegetables Based on the cultivation area under respective crops, only field crops such as paddy, black gram, wheat, potato and rapeseed and mustard are taken into account, as the production of other crops is not so substantial The total annual agricultural residue generated from paddy is 16 635 21 tonnes and from minor crops is 2 735 08 tonnes (Tables 4 4 and 4 5).

Table 4 4 Residue generation of major crop (1999-2000)

Crop	*Season*	*Production (t/y)*	*Total Production (t/y)*	*Type of residue*	*Crop / Residue ratio*[4]	*Residue production (t/y)*
	Summer	898 32		Straw	1 76	14 443 99
Paddy	Autumn	1259 07	8206 81	Husk and hull	0 267	2 191 22
	Winter	6049 42				

Source A E O (VLEW) Sarukhetri block 2000

Table 4.5 Residue generation of minor crops (1999-2000)

Crop	*Production (t/y)*	*Crop/Residue ratio*	*Type of residue*	*Residue production (t/y)*
Rapeseed & mustard	115 26	2 5[4]	Stalk	288 15
Black Gram	17 38	2 5[4]	Straw	43 45
Wheat	228 41	1 75[4]	Straw	399 72
Sesamum	18 64	1 3[5]	Leaves and branches	24 23
Potato	2604 64	0 76[5]	Leaves and stems	1979 53

Source A E O (VLEW) Sarukhetri block 2000

[3] Forest Survey of India 1996
[4] Baruah DC, Jain AK 1998
[5] School of Energy Studies, Jadavpur University 1999

Chapter 5
Biomass scenario in industries

5.1 Biomass generating industries

There are no large-scale biomass generating industries in the block. However, the small-scale flour mills, rice mills and oil expelling units comprise a source of biomass (residue) supply as a by-product of processing agricultural crops (Table 5.1)

Table 5 1 Type and distribution of biomass generating industries

Industry	*Units*	*Location (no of units)*	*Type and amount of residue generated*
Rice mill	39	Jasodhar pam(2), Belbari gaon(2), Majdia(2), Lachima(1), Chatla(3), Khudra bamunbari(1), Chengdi(1), Chinadi(2) Khudra amrikhuwa(4),Baramrikhuwa(1), Borghopa(2), Namsala(1), Bhogdia(1), Bagrirtari(1), Byashkuchi(4), Rangia(1), Khudra faladi(1), Kaljahipathar(1), Hariahkuchi(1), Kukarpara(1), Kamalabari(1), Pachim aladi(1), Barmara(1), Bayasa(2), Barkapla(1)	Husk 1320 15 t/y Hull 867 75 t/y
Oil mill	2	Belbari, Khudra amrikhuwa,	Oil cake 2 6 t/y
Flour mill	1	Burikhamar	NA

Source Primary survey 2000

5.2 Biomass generation and consumption industries

There exists no industrial units in the block which generate and consume biomass as an energy source. The industries listed in table 5 1 consume biomass as raw material and generate biomass (residues), which could be used for various purposes..

5.3 Biomass consuming industries

Table 5.2 Types and distribution of biomass consuming industries

Industry	*Units*	*Type and amount of biomass consumed*
Bell and brass metal	86	Coal 361 t/y
Restaurant/Hotels	18	Fuelwood 457 2 t/y

Source Primary survey 2000

Note Though bell metal units do not consume biomass but these comprise the largest share of industrial units in the block

Chapter 6

Biomass consumption and surplus availability

1 Land

1.1 *Surplus biomass from different land categories*

Table 6.1 Consumption and surplus availability of woody biomass, grass and shrubs

Type of biomass	*Land type*	*Generation t/y*	*Total generation t/y*	*Consumption t/y* Cooking fuel	Fodder	*Surplus/ Deficit t/y*
Woody biomass	Social forestry	6 323 99	23 941 98	31 068.02	-	-7126 04 (-13450 03)[3]
	Homestead	13 339 2				
	Misc. trees, groves	4278.79				
Grass and shrubs[1]	Fallow land	1 269 32	1 809 04	Not available	Not available	Not available
	Cultivable waste land	539 72				
Grass[2]	Barren land	46 38	1 677 12	-	1677 12	-
	Grazing land	1 630 74				

Source Table 4 1, Table 4 2 and Table 4 3, Primary survey 2000

1 Though cattle is allowed to graze in fallow and cultivable wastelands, but the quantity consumed is difficult to ascertain as the cattle feed in these areas intermittently

2. There is an acute shortage of grass for cattle feed as informed by the villagers during the primary survey, thus the entire grass production is utilized as fodder

3 This excludes the sourcing of biomass from Social Forestry Division plantations

1.2 *Agriculture*

Table 6.2 Crop residues from cultivable land

Crop type	*Generation t/y*	Consumption t/y Fodder	Cooking fuel	Fertilizer	*Surplus t/y*
Paddy					
Husk	1424 30	-	71 22	71.22	1281 87
Hull	766 92	766 92	-	-	-
Straw	1 4443 99	1 4443 99	-	-	-
Rapeseed & mustard	288.15	-	288 15	-	-
Black gram	43.45	-	43 45	-	-
Wheat	399 72	-	399 72	-	-
Sesamum	24 23	-	24 23	-	-
Potato	1979 53	1187 72	-	-	791 82

Source Table 4 4 & Table 4 5, Primary survey 2000

Note Primary survey indicated the utilization of 100% straw and stalk biomass by households as either fuel or fodder and out of the total husk generation, 35% is hull and 65% is husk

6.2 Industries

There are 42 biomass-generating units, out of which 39 units are rice mills, 2 are oil mills and 1 flour mill. There are 18 small restaurants and hotels which consume biomass in form of wood, and buy their supplies from the local market at the rate of Rs 180-200/quintal.

6.2.1 *Surplus agro residues from biomass generating industries*

Table 6.3 Surplus agro residues from biomass generating industries

Industry type	*Units*	*Generation t/y*	*Utilization t/y*	*Surplus t/y*	*End use*
Rice mill	39	Husk 1320 15 Hull 867 75	Husk 132 0 Hull 867 75	1188 15 -	10% of husk is sold, which is consumed as fuel and fertilizer 100% hull is sold for use as fodder
Flour mill	1	None	None	None	-
Oil mill	2	2 6	2 6	None	fish food and fertilizer
Total	42	2190 5	1002 35	1188 15	

Source Table 5 1, Primary survey 2000

6.3 Summary table

Table 6.4 Status on availability of biomass in Sarukhetri

Type of biomass	Generation t/y	Consumption t/y			Surplus/Deficit t/y
		Fodder	Cooking fuel	Fertilizer	
Woody biomass	23 941 98	-	31 068 02	-	–13450 03
Grass	1677 02	1677 02	-	-	None
Shrubs and grass	1809 04	Not available	Not available	Not available	Not available
Agri residues	19 370 29	16 398 63	826 77	71 22	20 73 67
Industry residues	21 90 5	867 75	66	68 6	1 188.15

Note Biomass generated from industry and agriculture land is mainly paddy residue Thus paddy residue has been accounted for under agriculture residue and industry residue.

Chapter 7

Surplus biomass availability

7.1 Woody biomass

The annual sustainable yield of woody biomass from homesteads and miscellaneous lands is far below the consumption levels, leading to a deficit in wood availability. The use of wood biomass is mainly for the end-use of cooking Thus there is no surplus woody biomass available in the block (Table 6 1, 6 4). The production of biomass from forest plantations (Social Forestry) though available, is not sufficient to sustain the operation of gasifier based power generating facilities.

7.2 Agriculture land

Net cropped area accounts for 7 807 93 ha (66 58%) of the block's total geographical area of 117 27 ha. Field crops such as paddy (*Sali, Ahu, Boro and Bao* varieties), rapeseed and mustard, black gram, *arhar*, wheat, sesamum and jute are grown in different seasons. Of all the field crops, *Sali* paddy (winter paddy) comprises primary crop covering an area of 4 201 ha followed by *Bao* (1 582 ha) and *Boro* (116 ha). Total annual production of *Sali* paddy is 6 049.42t, *Bao* 1 259.07t and *Ahu* 551.52 t (1999-2000) The total residue generation from paddy during different periods of the year is 16 635 21 t, of which 14 443 99 is straw and 2 191 22 is husk and hull Out of the total residue generated, 100 % of the straw production is utilised as fodder. The hull, which is generated during dehusking, and about 10% of the husk, are also utilised as fodder, fuel and fertilisers by the households. Thus the net available surplus paddy residue in the block is 1 281.86 t/y. The surplus biomass which is mainly husk is available at the rice mills at a cost of Rs 1 50 /kg during lean season and Rs 1/kg during the harvest season.

A number of field crops with lesser extent under cultivation than paddy are also grown as minor crops. These are namely rapeseed, mustard, black gram, sesamum, *arhar*, jute, wheat, potato and vegetables, covering an area of 651.78 ha, grown in different seasons. Out of these crops, rapeseed and mustard, sesamum, wheat, black gram and potato are found to be favoured for cultivation by the farmers, and occupy an area of 636.82 ha. Considering these crops as the dominant minor crops, the total annual residue generated is 2 735.08 tonnes (Table 7.2) Residues from minor crops are consumed as fuel, fodder and fertilisers, and do not have any commercial value.

Table 7.1 Residue generated from major crops (1999-2000)

Paddy	*Seasonal availability*	*Area(ha)*	*Yield[1] t/ha*	*Production t/y*	*Residue t/y*	*Surplus t/y*
Summer						
Boro	April-May	299.44	3 0	898 32	Husk 239 85	Husk 140 31
Ahu	June –July				Straw· 1581 04	Straw None
Autumn		1581 74	0 796	1259 07	Husk 336 17	Husk 196 66
Bao	Sept -Oct				Straw 2215 96	Straw None
Winter	Nov - Dec	4200 81	1 44	6049 42	Husk 1615 20	Husk 944 89
(Sali)					Straw 10646 98	Straw None
Total		**6081 99**		**8206.81**	**Husk. 2191.22**	**Husk 1281 86**
					Straw· 14 443 99	**Straw None**

Source A E O (VLEW) Sarukhetri Block 2000

Table 7.2 Residue generated from minor crops (1999-2000)

Minor crops	Seasonal availability	Area ha	Yield[2] t/ha	Production t/y	Residue t/y	Surplus t/y
Rapeseed & Mustard	Jan-Feb	174 64	0 66	115 26	288 15	Nil
Black Gram	Nov-Dec	34 76	0 5	17 38	43 45	Nil
Wheat	Mar-Apr	185 10	1 234	228 41	399 72	Nil
Sesamum	Nov	30 56	0 61	18 64	24 23	Nil
Potato	Dec-Feb	211 76	12.3	2 604 64	1 979 53	792 53

Source A E O (VLEW) Sarukhetri Block 2000

2 Industries

The industrial base in Sarukhetri is restricted to small-scale establishments mainly comprising bell metal units, flour mills, and rice and oil mills However, the bell metal units do not consume or generate biomass The flourmills consume biomass (wheat grain) but do not generate biomass residue. Thus rice mills and the oil expelling units are the only biomass generating industries These consume biomass as raw material, and generate biomass residues. The total annual residue generation from such units is 2 190 5 t, of which only 1 188 15 t (54.24%) is available as surplus, and the remainder (46%) is sold at Re 1/kg to households for consumption as fodder, fuel and fertiliser (Table 7.3). The surplus paddy husk is available throughout the year, but currently it being either disposed off by dumping it on roadside or burnt by the rice mills.

Table 7 3 Biomass generating industrial units in Sarukhetri

Industry type	No units	Residue generation (t/y)	Available surplus (t/y)
Rice mills	39	2187 9	1188 15
Oil mills	2	2 6	None
Flour mill	1	None	None
Total		**2 190 5**	**1 188.15**

Source Primary survey, 2000

[1] District Agriculture Office, Barpeta 2000

[2] District Agriculture Office, Barpeta 1999

Chapter 8

Biomass collecting mechanism and management

Seasonal availability and cost

Agricultural residues generated from major and minor crops comprise the sole source of biomass surplus available in Sarukhetri Paddy constitutes the major crop with four varieties (*Ahu, Sali, Boro and Bao*) being cultivated here. Minor crops include oilseeds (mustard & rapeseed, sesamum), black gram, wheat and potato. Bulk agricultural residues (straw and husk) are available from paddy during the harvesting season for different varieties from April to July, and September to December (Table 8.1) The intermittent period of four months from January to March and August are lean season for residue availability. Paddy straw is stored at the household level for fodder use, and local trading in straw among households is prevalent within 5-10 km radius of respective villages However, paddy husk and hull generation is concentrated in rice mills, as almost all households prefer to get the paddy processed at the local rice mills. Thus paddy husk is available throughout the year and has been considered as surplus biomass for power generation. However, the pricing varies with the season, with husk/hull available at Rs 1000/tonne during the harvest season and Rs 1500/tonne in the off-season (Table 8.1).

Minor crops selected for contribution to biomass production is based on the area under cultivation and production. In the present study rapeseed and mustard, black gram, wheat and sesamum have been considered. The biomass availability from these crops is restricted to five months in the year (February to April, and November-December) Owing to the low production of such crops and the associated use of the crop residues (100%) generated for fuel and fodder by the households; there is no commercial trading in residues from minor crops

Woody biomass from homesteads is available through out the year and households have access to same for end-uses of cooking and small timber. Though this wood is obtained free of cost, but at times during emergencies, households buy or sell wood at Rs 1800-2000/tonne within their village panchayat limits. Large-scale commercial trading in wood is not prevalent in the block. The plantations raised by the Forest Department are for community use but with access vesting with the Department. Thus there is no commercial value attached to it at present. The biomass from grazing lands, fallow lands, etc. available almost through the year with free access to the resources.

Table 8.1 Seasonal availability of biomass and pricing in Sarukhetri (1999-2000)

Crop	*Harvest season*	*Surplus residue availability (husk)*	*Quarter*	*Husk/hull price (Rs/tonne)*	*Straw price (Rs/tonne)*
Paddy					
Boro	April-May	54 17 t/year	Jan - March	Rs 1500	Rs 1500
Ahu	June-July	86 14 t/year	April-June	Rs 1000	Rs 1500
Bao	Sept -Oct	196 66 t/year	July- Sept	Rs 1000	Rs 2000
Sali	Nov -Dec	944 89 t/year	Oct - Dec	Rs 1000	Rs 1500
Rapeseed & Mustard	Feb -March	None	No commercial trading exists in residues of these crops		
Wheat	March-April	None			
Sesamum	Nov	None			
Black gram	Nov -Dec	None			
Fuelwood	All year round	None	All quarters	Rs 180-200/ quintal	
Grass & shrubs	All year round	None	All quarters	Zero cost	

8.2 Sourcing mechanism

8.2.1 Agriculture residues

With the major share of cropped area under paddy cultivation in Sarukhetri and given the flat terrain, crop residues are easily accessible. Further, agriculture tracts are located close to the main settlements within1 km radius. Harvesting of major and minor crops and the collection of crop residues is seasonal activity, handled by the farmers themselves. While collection and storage of straw (paddy as well as minor crops) is carried out at the household level, dehusking of paddy is undertaken at the local rice mills (39) throughout the year and surplus residues are available at the mill premises Almost every village has access to a rice mill, located within 5 km radius of the respective villages. In addition oilseeds are also processed at the local mills to generate limited amounts of oil-cake. As straw and oil-cake are wholly (100%) consumed by households, *rice mills are main source areas for supply of surplus biomass (husk)* If collection of husk for power generation is to become a regular activity, arrangements with the mill owners will have to be worked out for supply of the desired quantum of husk on a weekly or fortnightly basis Thus mills in the respective villages can become the collection centres.

8.3 Biomass costing

In the context of the crop residues availability scenario in the block, it is observed that crop residues are available at a zero cost as these are sourced at household level. The consumption of straw (100%) from both major and minor crops residues leaves no scope for commercial trading for supply to potential biomass based power facilities. Thus paddy husk is the only surplus biomass source which can be procured commercially Because dehusking is undertaken at rice mills, currently the bulk of the paddy husk generated by rice mills is being disposed off as wastes. Of the total husk generated, only 10% is sold at Rs 1000-Rs1500/tonne Hence the procurement of surplus husk for power generation at prevailing market rates or lower will not only ensure productive disposal of the husk but also be an incentive for the mill owners. In addition to the cost of husk, the transportation of the biomass from the mills to the power production/storage site will also add to the landed cost The communication network in Sarukhetri comprises a network of metalled (PWD) and fair weather roads connecting all the villages (Annex 3). Goods are generally transported within the block and outside on headloads, bicycles and handcarts Carts can be hired locally at the rates ranging from Rs 20 to Rs 30 for a full load of 200 kg for up to distances of 5 km. Trucks are also available at rates ranging from Rs 700-Rs1000 for full load for distances up to 50 km But given the low volume of surplus biomass available and the scattered distribution of the rice mills, the procurement of husk would be restricted to an average of about less than 5 km Thus handcarts would suffice for the transportation of the husk and the transportation cost would be Rs 125/tonne (5 cart loads of 200kg at @Rs 25/cartload). The labour cost for loading and unloading is included in the cost of hiring the cart Hence the cost of per tonne of paddy husk including transportation works out to Rs 1125/tonne for supply to the power generating site.

Chapter 9

Biomass consuming industries

9.1 Biomass consuming industries

Sarukhetri block is famous for the bell and brass metal industry. There are about 86 units in the small-scale sector scattered all over the block. In addition, there are 39 rice mill, 2 oil mills and 1 flour mills in the block. Other than these industrial units, there is no significant presence of industrial activity The bell and brass metal units consume coal as fuel, which is imported from outside the block. The average fuel consumption of such units is 10-15 kg of good quality coal daily The rice and oil mills biomass (paddy and oilseeds) as raw material only and do not use biomass as fuel. Therefore, there is no direct use (as energy source) of biomass resources by local industrial units Table 9.1 presents the distribution of industries in the block.

Even though biomass consuming industries are absent in Sarukhetri, other establishments that consume biomass are the restaurants and tea stalls located in the villages. About 18 small restaurants, mostly tea stalls, are found in the Sarukhetri block. Such units consume an average of 69.59 kg firewood daily or 457.2 t/y wood annually, and burn fuelwood in mud cookstoves. This wood supply is procured locally at the rate of Rs 180-200/quintal. The use of improved cookstoves in such establishments would help in reduction of the firewood consumption by about 20-25% resulting in considerable firewood savings annually However, field trials on energy savings from improved cookstoves at individual level are yet to be undertaken in the block. Thus energy savings cannot be computed based on assumptions.

Table 9.1 Distribution of industries in Katigorah

Industry	No of Units	Location
Brass and Bell metal	86	Almost all villages in the block
Rice mills	39	25 villages (see Table 5 1)
Oil mills	2	Belbari, Khudra amrikhowa
Flour mills	1	Burikhamar

Source Primary survey 2000

Chapter 10

Possible power generation potential, location and economics

The current annual electricity consumption in Sarukhetri is 1 236.65 MWh, of which domestic consumption is 873.16 MWh (ASEB 2000) The annual domestic electricity demand if all the households in the block were to be electrified (*based on the current average monthly consumption of 50 units per household)*, is 5534 MWh. Thus there is a power deficit of about 84% in the domestic sector. Among the various sectors, domestic sector is the largest consumer (70 61%) followed by commercial sector (15.88 %), industry (11 62%) and public utilities (1.89%) [ASEB 2000]. With the power supply coming from the grid, it is envisaged that with the expansion of the grid network and the high percentage of non-electrified villages, there will be a rise in the domestic demand for power in future. At present, ASEB does not have any plans to electrify the 26 un-electrified villages (40%), which implies that there is potential for renewable energy technology interventions in rural electrification Thus an alternative option for supplying power is by generating power through biomass conversion routes, particularly at the village-level through gasifier based decentralised systems or through centralised power generating units connected to the existing grid

10.1 Power generation potential

Given the biomass resources assessed and their utilization in the study block, agriculture residues emerge as the most promising source. The availability of surplus crop residues provides an option for power generation through gasification as no surplus woody biomass is available for power generation. This is supported by the fact that annual consumption of firewood (31 068 t) exceeds the total generation of 23 941.98 t. Under such circumstances, there exists no potential for utilization of wood for power generation. The major agricultural crop residue comprises straw and husk generated from paddy, and contributes 16 635.21 tonnes (85 %), of the block's total annual biomass production of 19 370.29 tonnes. Straw is a major source for fodder in the villages and the entire (100%) straw production is utilised at the household level, therefore the total straw biomass amounting to 14 443.99 t/year cannot be considered. Rice husk contributes 2191 22 t/year, of which approximately 766.92 t is hull. The entire hull production is utilised as fodder and an additional 10% of the remainder husk production finds its utilization as fertilisers and homefire burning Therefore the potential rice husk biomass available is only 1281.86 t/y Further, minor crop residues such as rapeseed and mustard, wheat, sesamum and black gram are also used as fuel, and so no surplus can also be expected from these crops for any other utilisation.

Considering the processing and transportation losses @ 20% of the total surplus available, a net amount of 1025 49 t/y is available in the block, This surplus will be able to generate 1 872.89 kWh daily through dual fuel-based gasifier (Tables 10 1 and 10.2)

Table 10.1 Biomass based power generation potential

Type of biomass	*Surplus biomass available (t/y)*	*Actual biomass available[1] (t/y)*	*Biomass fuel input required for gasifier with dual fuel mode*
Rice husk	1281 86	1025 49	1 5 kg/kWh

[1]Considering 20% as processing loss

Table 10.2 Potential power generation capacity (kW/day)

Type of biomass	Power generation potential (gasifier with duel fuel mode)		
	24 hr supply	12 hr supply	6 hr supply
Rice husk	78 04 kW	156 07 kW	312 15 kW

10.2 Location of biomass based power generating units

In light of the available surplus biomass and the large number of un-electrified villages in the block, biomass-based power generation at the centralised level is not a practical option. But given the current biomass scenario, the capacity, location and distribution of biomass based power generating units will depend on the potential biomass available per day. Since the surplus biomass available is only 2 80t/day, biomass based power generation calls for decentralised applications on a smaller scale to be operated under specified periods Thus it implies that all the 26 un-electrified villages (Annex 4) cannot be completely electrified through gasifier systems alone. However, based on the current availability of surplus crop residues, there is scope for electrifying clusters of villages with provision to supply power to select households, restricted to of 5-6 hours daily, for lighting and small scale end-use applications Given the distribution of rice mills in the block, 5 clusters consisting of 14 villages and 4 individual unelectrified villages have been identified for availing biomass based power supply. Depending on the household population of the villages, 9 gasifier systems of differing capacities of 25 kW, 30 kW and 50 kW can be installed (Table 10 3 and Annex 5) The biomass supply for such power generation will be sourced from the rice mills located in and around the villages

Table 10.3 Distribution of potential power generation sites

Cluster	Biomass source (location of rice mill)	Biomass availability t/y	Gasifier capacity location	Operating hours/day	Non-electrified villages and no of households	Villages to be electrified
I	Bar Amrikhowa Khudra Amrikowa Namsala Lachima	175	50 kW Bar Amrikhowa	5-6	Bar Amrikhowa (209) Dewan Khetri (4) Now Kuchi (10) Balipara pam (12) Balipara pathar (26)	Bar Amrikhowa Dewan Khetri Now Kuchi
II	Barmara Khudra Faladi Bhogdia Byashkuchi	150	50 kW Barmara	5-6	Barmara (271)	Barmara
III	Pachim aladi Belbari Byashkuchi Barkapla	125	30 kW Pachim aladi	5-6	Pachim aladi (41) Pub-aladi (25) Kaldia pathar (21)	Pachim Aladi Pub Aladi Kaldia pathar
IV	Kamalabari Chinadi	75	25 kW Kamalabari	5-6	Kamalabari (75) Bagrirtari (64)	Kamalabari Bagrirtari
V	Barghopa Bagrirtari Chengdi	100	30 kW Barghopa	5-6	Barghopa (190) Patlarkur (33) Chengdi (68)	Barghopa
VI	Chatla Khudra Bamunbari	100	30 kW Chatla	5-6	Chatla (213) Gohia Chatla (261) Khudra bamunbari (144) Kaldia	Chatla -
VII	Rangia Kaljahi pathar Jasodhar pam	100	30 kW Rangia nadir pam	5-6	Rangia nadir pam (177) Rangia (149)	Rangia nadir pam
VIII	Sariahkuchi Bayasa	75	25 kW Sariahkuchi	5-6	Sariahkuchi (28) Garartari (66) Agdia(4)	Sariahkuchi Garartari Agdia
IX	Kukarpara Majdia	75	25 kW Kathalburi	5-6	Kathalbhuri (49) Bar faladi (10) Gadeshali pam (209)	Kathalbhuri Bar faladi Gadeshali pam

10.3 Economics

The cost of generation per kilowatt of power would depend on the capacity of the system and its application. MNES provides a capital subsidy of 90% for gasifier based systems in the North Eastern region irrespective of the capacity. Therefore under the present circumstances, subsidy can be availed of for any capacity. Financing can also be availed of, from IREDA at low interest rate, which for NE region is only 2.5 %. A 50 kW capacity rice husk based gasifier operating on dual fuel mode for 6 hours daily would consume about 14 tonne crop residue and 900 litres of diesel per month (*Diesel*

input of 100 ml required for generating one unit of electricity) In case of 25 kW and 30 kW gasifiers, the corresponding figures for crop residue and diesel would be 6.75 tonne and 450 litres and 8.1 tonne and 540 litres respectively. Diesel is available locally at price of Rs 17/litre Since the consumption of diesel is low, the major concern would be related to biomass. As crop residue is limited, proper storage facilities with capacities for sustainable operation have to be developed It is presumed that biomass for power generation would be procured from the rice mills located in the villages within the clusters identified or from neighbouring villages Crop residue (husk) is currently available at prices ranging from Rs 1/kg – Rs 1.50/kg, but there would be an additional cost added, which relates to transport. The cost for biomass transportation would be limited, as transportation would be mainly through handcart at a cost of Rs 20 for a load of 200-250 kg for up to 5 km. For distances up to 50 km, trucks are available at Rs 700-1000 daily The above discussion provides information related to the total fuel cost per kWh generation, but detail cost per kWh generation would depend on the capacity of the system and the distribution network. Gasification systems based on dual fuel operation are commercially available, the capacity being limited to 500 kW in the country Table 10 4 provides an approximate cost estimation for biomass based power generation under desired capacities

Table 10. 4 Cost estimation for biomass based power generation

Sl No	Capital costs		Proposed capacities		
			50 kW	**30 kW**	**25 kW**
1	Gasification unit, cooling cleaning system and instrumentation @ Rs 7500 per kW		375 000 00	225 000 00	187 500.00
2	Generating set @ Rs 4 000 – 5 000 per kW		200 000 00	150 000 00	125 000 00
3	Erection & commissioning (approx 15%-20 % of capital cost of gasifier and generator)		86 250 00	56 250 00	46 875 00
4	Cost of civil works (foundation, engine room, water supply, drainage, etc) @ Rs 2000 per kW but the cost would be about 50 % more for system less than 100 kW capacities		150 000 00	90 000 00	75 000 00
5	**Total**		**811 250.00**	**521 250.00**	**434 375.00**
6.	**B. Operational expenditure per month (for running 6 hours daily)**				
7	Fuel	Diesel @ Rs17 00 per litre	15 300 00	9 180 00	7 650 00
		Biomass @ Rs 1 000 00/ tonne*	13 500 00	8 100 00	6 750 00
8		Cost for transportation of biomass @ Rs 125 00 per tonne	1 687 50	1 012 50	843 75
9	Labour	Skilled worker (1) @ Rs 4000/month	4000 00	4000 00	4000 00
		Semi skilled worker (1) @ Rs 2 000 / month	2000 00	2000 00	2000 00
10	Cost of lubrication @ Rs 250 per month		2 50 00	2 50 00	125 00
11	**Total**		**67 225 00**	**36 737.50**	**21 368.75**

Note: The above estimates do not include transmission and distribution cost as the length of distribution would be variable The costs are indicative and are based on the survey of the current market prices, which are liable to change *It is also expected that the cost of biomass will reduce by at least 25%-50% when procured in bulk on a regular basis

Chapter 11
Recommendations and proposals

The biomass resources available in Sarukhetri are in the form of wood, grass, agriculture residue, and animal dung The current uses of these resources are wood for cooking, dung and residues for manure, and fuel and fodder, respectively The current power supply-energy consumption scenario revealed that domestic sector is the major consumer, followed by commercial sector (restaurants). Industrial power demand is insignificant in the absence of any large-scale industries except for small-scale units such as bell metal and rice mills.

The consumption pattern of woody biomass in the block, with the consumption exceeding the sustainable yield, leaves no scope for surplus woody biomass availability. However, husk generated from paddy crop constitutes the primary surplus biomass in the study block Given the limited surplus residue availability of 1281.86 t annually and the scattered distribution of unelectrified villages, *centralized generation of power is not possible* But **decentralized power production is a feasible alternative** for electrification of cluster of villages This option has significance as ASEB (Assam State Electricity Board) has no immediate plans of connecting the unelectrified villages to the grid Moreover, the major consumer is the domestic sector with low power demand The gasifiers could be installed at the unelectrified villages nearer to the rice mills where procurement of the husk from the rice mills will be easy and economic. The power generated could thus electrify the village as well as the nearby villages. Thus, the following options are recommended for dissemination of gasifiers of power generation at decentralized level.

- Gasifier capacities of **50kW, 30kW and 25 kW** can be installed at the villages depending on the amount of husk available from the rice mills. Thus **2 (50kW), 4 (30kW) and 3 (25 kW)** gasifiers could be operated to feed 18 unelectrified villages. With limited biomass based power potential in the block, the dissemination of gasifier technology needs to be demonstrated on a pilot scale to convince both probable producers and consumers of the benefits of the technology. Given the pattern of MNES subsidy, it is advisable to initiate power production with a demonstration unit at Bar Amrikhowa or Chatla village because of their proximity to a number of rice mills. This can be initiated by ASTEC, which is the renewable energy development agency for Assam, in collaboration with the local ASEB division. The ASEB could oversee the operation and maintenance of the system Once the credibility of the pilot system is established and the villagers convinced of the benefits of the technology, NGOs or village level societies in technical collaboration with ASTEC could install the other gasifiers Subsidy can be availed

from MNES for such system or finances can also be mobilized through IREDA in form of soft loans. Village level committees could be established to supervise the collection, transportation and processing of the biomass feedstock. For operation and maintenance of the gasifiers, local youth are to be trained and an honorarium given to them for the services rendered.

Rice mills, which are main source points of husk generation, will constitute the main suppliers with no involvement of households. They would arrange for the transportation of the same to the power generating sites. Thus adequate storage facilities should be set up at the generating sites for storage of biomass.

Though involvement of private investment is encouraged in power production, but owing to the limited scale of surplus biomass available and the potential for only low capacity of gasifiers, entrepreneurs may not be interested in such ventures in the block. Hence, if initiative is taken either by ASTEC or NGOs, then only can biomass based power generation in the block will be possible.

In the absence of any policy for private power generation in the state, permission from ASEB would have to be obtained for generation and public distribution. It is imperative for the producers to make a long-term formal agreement with local ASEB (Barpeta Electrical Sub-Division) authority for power production and supply. Without such arrangement, the implementation of such endeavours may be fraught with operational difficulties.

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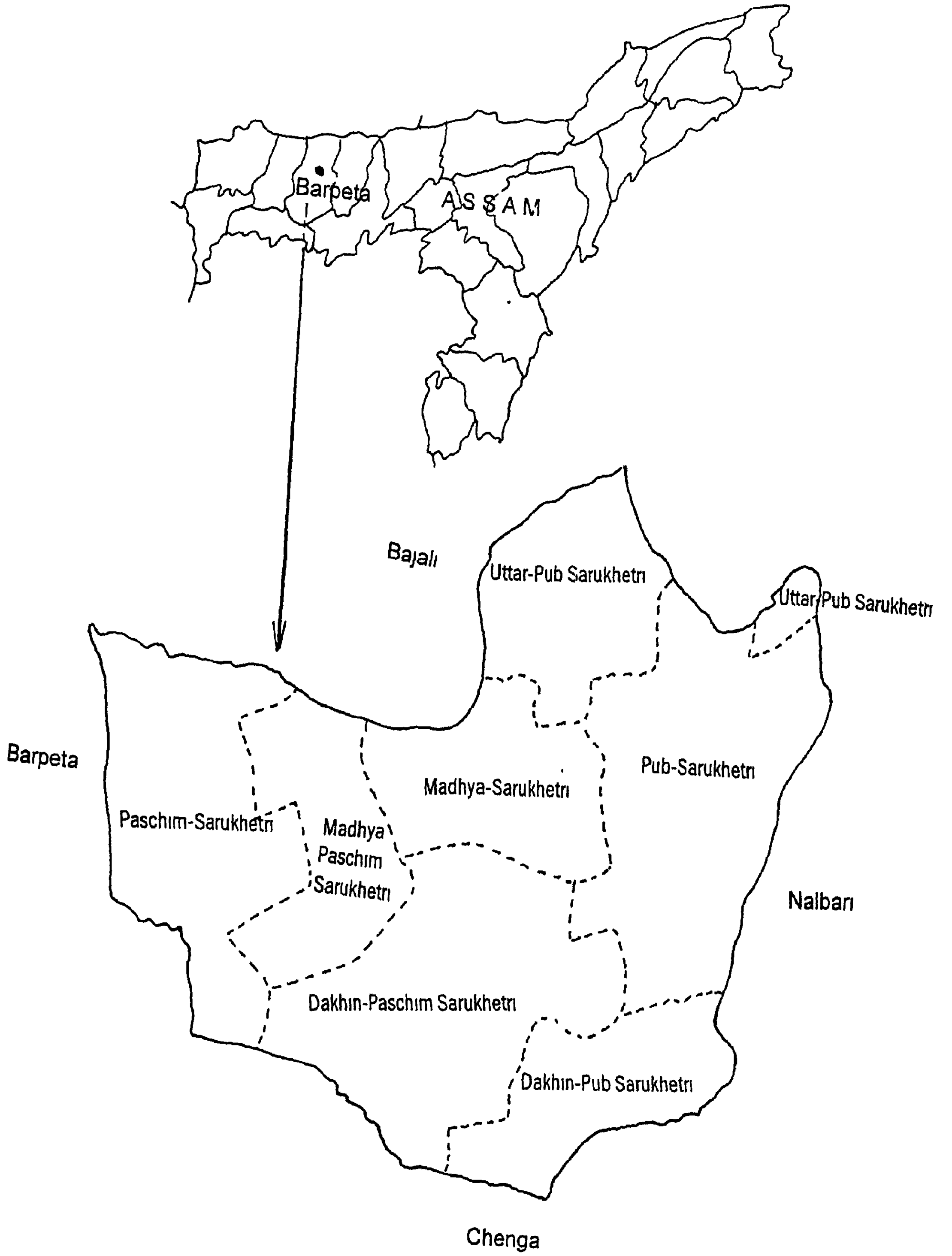
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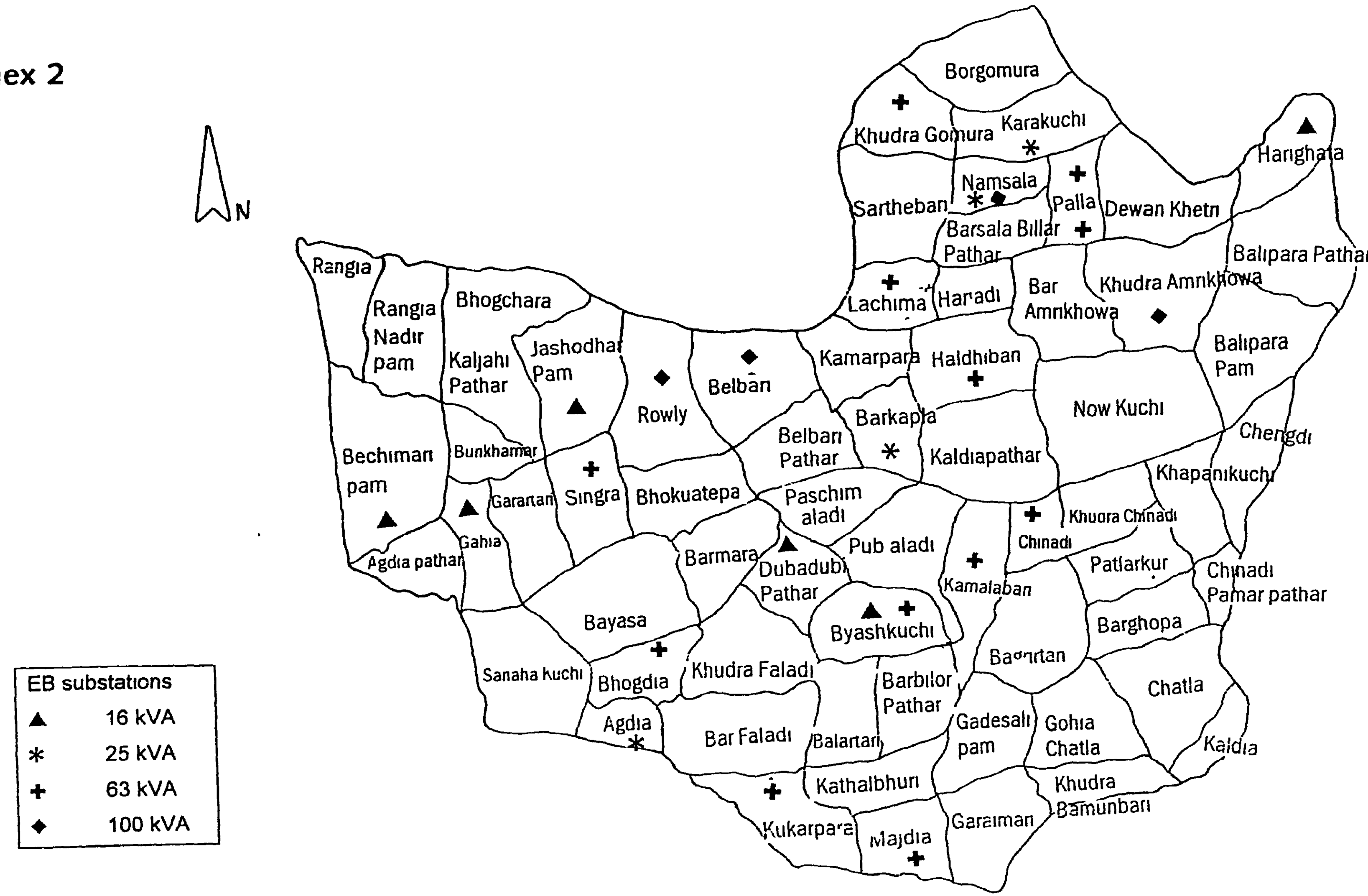
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Annex 1



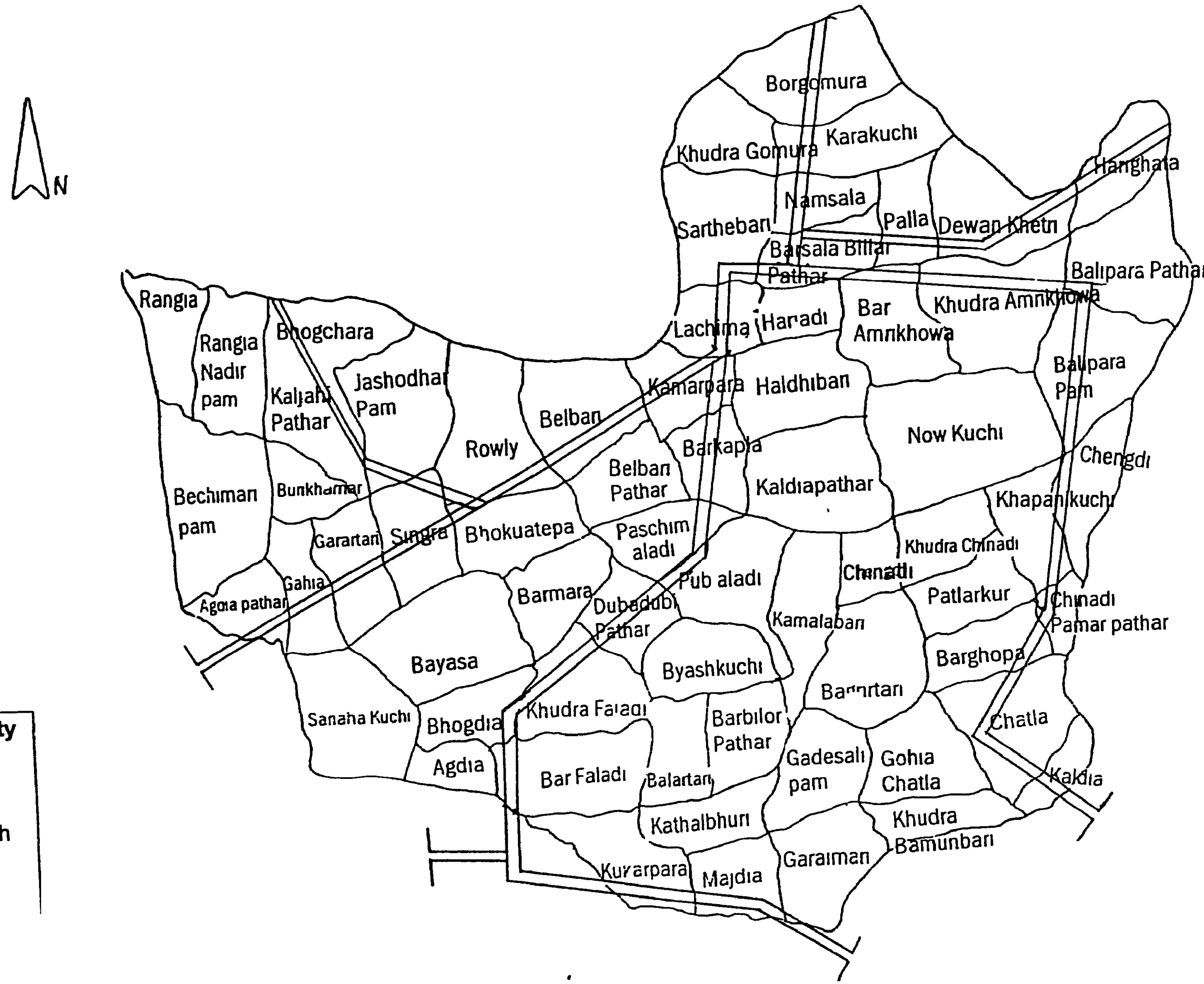
Annex 1. Location of Sarukhetri block and its Gram Panchayats

Annex 2



Annex 2 Distribution of villages and EB sub-stations in Sarukhetri

Annex 3



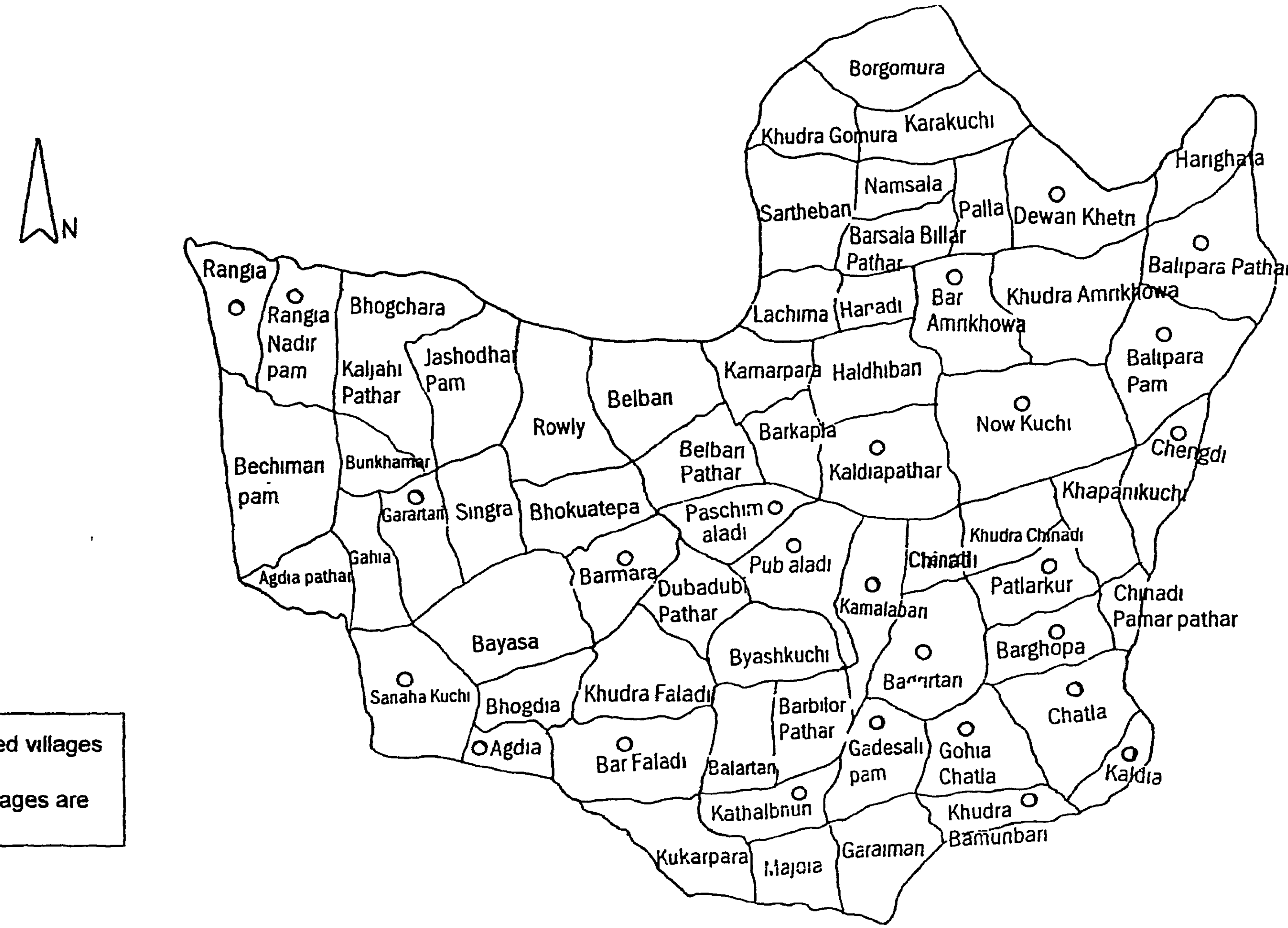
Road connectivity

PWD road

Most villages are connected to each other by fair weather roads

Annex 3 Road connectivity in Sarukhetri

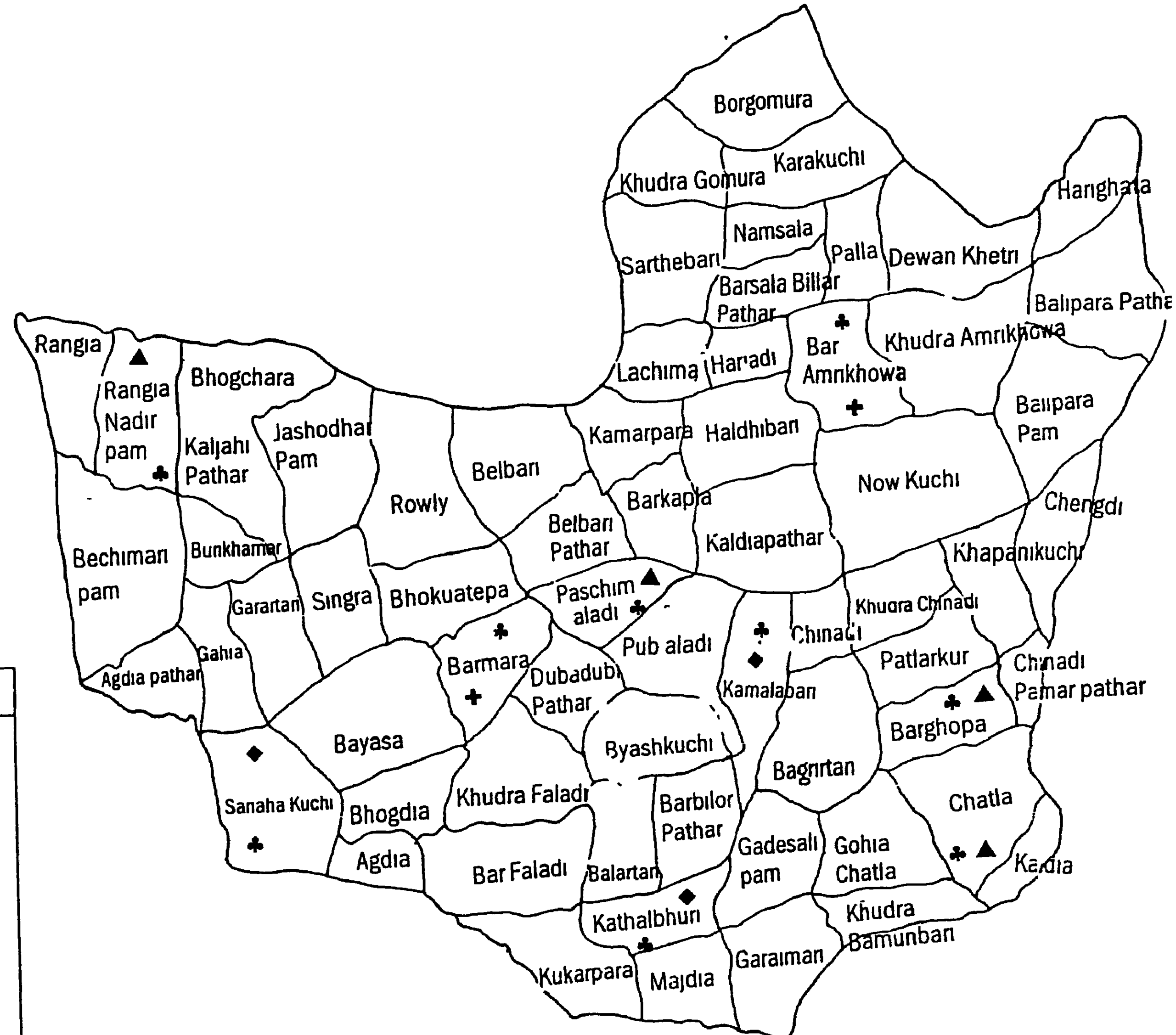
Annex 4



Annex 4 Distribution of unelectrified villages in Sarukhetri

Annex 5





♣ Biomass collection and storage site

Generation sites	Gasifier capacity
Bar Amrikhowa	50 kW ✚
Barmara	50 kW ✚
Paschim aladi	30 kW ▲
Kamalabari	25 kW ◆
Barghopa	30 kW ▲
Chatla	30 kW ▲
Rangia nadir pam	30 kW ▲
Sarihakuchi	25 kW ◆
Kathalbu ·	25 kW ◆

Annex 5 Potential power generating sites and biomass collection and storage centres in Sarukhetri

Annex 6 Survey schedule

Biomass Assessment for Power Generation in Sarukhetri Block, Barpeta district, Assam

Village schedule

General information

1. Village Name.______________ 2. Geographical Area________ Ha

3. No of Households _____4. . Population____ 5. Major ethnic group_________

6 Type of connecting road. metalled/foot track/motorable (unmetalled)

7. Distance from

Item	Distance (km)
State/National highway	
Grid	
Bus stand	
Railway station	
Post office	
Bank	
Hospital/dispensary	
Cooperative/kerosene depot	

Electrification

8. Village Electrified (Yes/No)

If yes number of households electrified _________

9 Source of electrification. Grid/Diesel Gen sets (capacity) kVA

10 No Of hours power is available (summer) ________hrs/day

11. No. of hours power is available (Winters): ________hrs/day

12. Types of connections

Types	Number
Domestic	
Agriculture	
Commercial	
Industries	
Others	

13. Electricity tariff Billing/Flat rate
Average rate _______Rs/month/connection/point

Land details

14 Land Area (in bigha/ acres)

Total cropped area	
Net irrigated area	
Gross irrigated area	
Non irrigated area	
Forest land and species of trees grown	
Area not available for cultivation	
Grazing/ Fallow land	.
Land under Non Agricultural uses	

15.Land ownership

Land category	Number of households
Large (> 150 bigha)	
Medium (60- 150 bigha)	
Small (15- 30 bigha)	
Marginal (< 15 bigha)	
Landless	

16 Crops Grown

Crops grown	Area (Bigha)	Yield (Mon/Bigha)	Total production (Mon/year)	Type of Agri residue	Crop - residue ratio	Total residue Qtl/year .
				1 2.		
				1 2.		
				1. 2.		
				1. 2		
				1. 2.		
				1 2		
				1. 2		

17 Livestock details

Cow	Bullock	Buffalow	Goat	Pigs	Poultry	Others

18. Total Dung __________Kg per day Use of dung ____________

19 Drinking water details

Source	Numbers	Distance (km)
Handpump		
Wells		
Taps		
Tubewell		
Stream		
Tank		
Others		

20. Irrigation details

No of canals Govt. & Private	
Area irrigated by canal (bigha)	
No of tanks	
Area irrigated by tanks (bigha)	
No of wells	
Area irrigated by wells (bigha)	
No of Borewells	
Area irrigated by borewells (bigha)	
No of lift irrigation projects	
Area irrigated by lift irrigation (bigha)	
Other sources - Name	
Area irrigated by other sources (bigha)	

Energy

21. Energy sources

Fuel	End use	Source	Price (Rs)	Distance (km)
Firewood				
Animal dung				
Crop residues				
Kerosene				
Diesel				
LPG				
Coal				
Others				

22. Small industries

Industry	Number	Capacity (HP)	Raw material (Mon)	Waste generated (Mon)
Flour mill				
Rice mill				
Saw mill				
Others				

23 Collection of wood

Season of collection	Source	Access (right to) for

Access fuel/fodder/small timber/timber

Biomass utilisation

24. Availbility of biomass

Is biomass available?	Yes/No
Whether household sell biomass	Yes/No
To whom and at what rate?	
No. of times HH sell biomass per year	
Place of storage	
Transportation arrangement	
Cost of transport	

25 Utilisatuon of biomass

Crop	Crop residue	Biomass utilisation Mon/year					Total Mon/year
		Fuel	Fodder	Roofing	Fertilizer	Others	
	1. 2						
	1 2.						
	1. 2.						
	1. 2.						

Additional Remarks (if any)

Biomass Assessment for Power Generation in Sarukhetri Block, Barpeta district, Assam

Household Level Schedule

Village____________

I Household details

1 Head of the household____________________ 2 Respondent Name ______________

3. Family details

	Number	Education level	Occupation	
			Primary	Secondary
Men				
Women				
Children (< 15 yr)				

House type

Construction material: bamboo/thatch/tin/cement No. of rooms Pucca:

- Electrified. Yes/No Kuchha

Land Ownership details

Item	Acres/ bighas	Lease	
		Given	Taken
Total land			
Agricultural land			
Irrigated land			
Unirrigated land			
Fallow land			
Garden/orchard			
Forest land			
Others			

6. Livestock details

Cow	Bullock	Buffalow	Goat	Pigs	Poultry	Others

7. Total Dung _________Kg per day Use of dung ___________

II Biomass availability and Utilisation

8 Crops Grown

Crops grown	Area (Bigha)	Yield (Mon/Bigha)	Total production (Mon/year)	Type of residue	Crop residue ratio	Total residue Mon/year
				1 2		
				1 2		
				1 2		
				1 2		
				1 2		
				1 2		

9. Availability of biomass and utilization

Biomass →				
Biomass cannot be collected (in Mon)				
Whether household sell biomass				
Rate of biomass (Rs/mon)				
Place of storage				
Period of storage (no of months)				
End uses				

10 Utilization of biomass

Crop residue	Total prod Mon/year	Biomass utilization (Mon/year)							
		Fuel	Fodder	Roofing	Fertilizer	Given free	Sold	Burnt	Left at the field

10 Sale of Biomass

Biomass	Where sold	To whom sold	Rate	When sold	Transport		Distance	End use
					own	Buyer's		

III Fuel consumption

11 Fuel consumption

Fuel	Unit	Cooking	Water heating	Space heating	Lighting	Others	Season wise utilization (in % age)		
							Summer	Monsoon	Winter
Firewood	Kg/day								
Kerosene	lit/month								
Crop residue	Kg /day								
Cow dung	Kg/day								
Coal	kg/month								
LPG	cylinder/month								
Diesel	lit/month								
Electricity	Units								
Biogas									
Others									

12 Fuel source and availability

Fuel type	Source	Qty	Easily available	Free of cost	Cheapest	Alternative not available	Cannot buy	Preference (rank)
Firewood								
Kerosene								
Crop residue								
Cow dung								
Coal								
LPG								
Diesel								
Electricity								
Biogas								
Others								

13. Device ownership

End use	Device type	Numbers	How many are used simultaneously	Hours used/ day
Cooking	• Traditional stove • Improved stove • Kerosene stove (Wick/pressurized) • LPG stove • Biogas stove			
Lighting	• Kerosene wick lamp • Kerosene lantern			

End use	Device type	Numbers	How many are used simultaneously	Hours used/ day
	• Solar lantern • Petromax • LPG petromax • Bulb/Tube (give wattage and hrs of use of each bulb per day)			
Space Heating	• Electric heaters • Traditional stove			
Other assests	• Radio/Tape recorder • Television • Scooter/Motor bike • Cycle • Thresher • Tractor • Diesel generator • Flour mill • Others			

14 Electricity bill ________________Rs/month

IV Economic status

15 Income range

Less than Rs 1000/-	
Between Rs 1000/- and Rs 5000/-	
Between Rs 5000/- and Rs 10000/-	
More than 10000/-	

16. Total household expenditure (Rs/month)------------------------

17. Any other observation by the surveyor.

Biomass Assessment Study in Sarukhetri block, Barpeta district, Assam

SURVEY SHEET FOR INDUSTRY

1 Type of industry____________ 2 Respondent ______
(Establishment Year)

3 Address

Plot No	Village/Town	Taluka	Distt

4. Description of activity

Round the year	If, Seasonal (month)	Annual turnover (Rs)	Raw material		Product manufactured
			Type	Source	

5 Energy used in manufacturing & its source

Human labour		Type of energy source					
No of persons	No of hr. per day	Elec	Coal	Fire wood	Agri waste	Diesel	Other (Pl. sp)

6 Energy supply & expenditure

Type of energy	Purchase		Expenditure/Cost				
	Qty.	Source	Basic	Cartage	Handling	Taxes	Stores

7 Energy demand & its application

Energy	Requirement		Application	Type of firing*	Alternative fuel	
	Year	Day			Qty.	Cost

*Stationary Stoker, Fluidized bed and others

8 Electricity and alternative fuel

Sanctioned load	Peak requirement	Monthly consumption	Hrs of operation	Capacity of D G set	Monthly operated (hrs)	Consumption	Total

9 Details of Biomass (as fuel)

Type	Qty.	Use direct/briquetting, cutting, shredding	Storage			
			For days	For months	Qty	Place

10 Reasons for using this fuel

Type of fuel	Easily available	Free of cost	Cheap estb	Can't afford other fuel	No other fuel available	Other reason (Pl Sp.)

11 Future plan . Expansion : Energy supply

12 By product (Biomass) and its utilisation

By-product	Quantity (Ton/year)	Consumption (ton)			Enduse
		Self	Sold	Free	

13 Details on sold by product

Rate/ ton	Distance	Mode of transport	Rate/trip

Biomass Assessment Study in Sarukhetri block, Barpeta district Assam

SURVEY SHEET FOR COMMERCIAL ESTABLISHMENTS

(Hotels, Lodges, Guest houses, Institutions) Sheet No ______

A. General information

1. Category of establishment (tick) Hotel/ Lodge/Guest house/Hostel/IB/CH
2. Name of establishment ___________ Respondent's name ____________
   Years of functioning ____ No. of rooms____kitchen/laundry/offices (tick)
3. Electricity supply Summers ______hrs/dy Winters______hrs/dy
4. Average monthly electricity bill : _____Cost of electricity unit: __________

B. Lighting load

1. Electricity

No. of bulbs: __________ No. of tubes _________Wattage. ___________

Other lighting devices· _____________

2. *Non electric lighting sources*

Petromax (nos). _____________ LPG Petromax (nos)· ___________

3. *Space heating (only lodging area)*

No. of months of space heating _____________

APPLIANCE USED FOR SPACE HEATING

Type of appliance	Rooms	Kitchen	Restaurant	Others (specify)
Electric heater _____W)				
Blower (___W)				
Wooden Bukhari				
Coal Bukhari				
Any other				

APPLIANCE USED FOR WATER HEATING

Type of appliance	Capacity (liters)	Total Nos
Fuel wood		
Boiler (_____)		
Geyser (_____W)		
Immersion rod		
Solar heating		

4. Cooking

Type of appliance	Numbers
Toaster (_____W)	
Chulha	
Kerosene stove (wick)	
Kerosene stove (pressurized)	

5 Other devices

Devices	Number
Television (_____W)	
Music system (_____W)	
Refrigerator	
Any other	

C. Have you got any generator (Diesel/Kerosene/Petrol) (tick)?

Parameter	
Total generating capacity (kW/kVA)	
Average daily utilisation (hrs)	
Consumption of fuel per hour (liters)	

D. Energy consumption pattern

Fuel type	Physical unit	Total Consumption (in physical units)	Total monthly expenditure (Rs)
LPG	Cylinders/month		
Kerosene	liters/month		
Firewood	kgs/month		
Coal/Charcoal	kgs/month		
Diesel/petrol	liters/month		
Others			

P=Peak season, S=Slack season

Hot water requirement Peak: _______lts/day or room

Slack ______lts/day or room

Biomass Assessment Study in Sarukhetri block, Barpeta district, Assam

SURVEY SHEET FOR COMMERCIAL ESTABLISHMENTS

(Shops & restaurants) Sheet No _

A. General information

Business type____________________ Respondent's name________

Number of employees' _____________ Business season (specify months): _____

B. Electrification details

1. Electrical appliances and their usage

SN	Type of appliance	Total nos.	Watts	Average hrs used daily
A.	LIGHTING			
1	Bulbs			
2	Tubes			
3	CFL			
B.	SPACE HEATING			
1.	Electric heater			
2.				
C.	WATER HEATING			
1.	Boiler			
2.	Geyser			
3	Immersion rod			

1. Supply of electricity Summer:_______hrs/day winter:________hrs/day

Cost of electricity unit: ___________

C. Other power sources

1. Non electrical appliances and their usage

Activitiy	Type of appliance	Total Nos	Hours of usage daily
LIGHTING	Kerosene wick lamp		
	Kerosene Hurricane lantern		
	Petromax		
	Solar lantern		
	Battery lamp		
	LPG petromax		
SPACE HEATING	Wooden Bukhari		
	Coal Bukhari		
	Open fire place		
WATER HEATING	Chulha		

Activitiy	Type of appliance	Total Nos	Hours of usage daily
COOKING	Chulha		
	Kerosene stove (wick)		
	Kerosene stove (pressurized)		
	LPG		

2 Have you got any generator (Diesel/Kerosene/Petrol) (tick)? Yes / No

SN	Parameter	
1	Number of gensets	
2.	Total generating capacity (kW/kVA)	
3.	Average daily utilisation (hrs)	
4	Consumption of fuel per hour (litres)	

D. Energy consumption pattern

Fuel type	Physical unit	Source	Mode of transport with distance	Total Consumption	Total expenditure (Rs)
LPG	Cylinders/m				
Kerosene	Liters/month				
Firewood	kgs/month				
Coal/ Charcoal	kgs/month				
Diesel	litre/month				
Petrol	litre/month				
Others					

Has the price of firewood increased/decresed in the last two years If so by how much ?

Rs /KG/tractor troley/trade

E. Power requirements (for lighting only)

1. How many additional light points do you need
2. How many additional hours of supply are required?

Peak season._________hrs/day Slack season:____________hrs/day